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THE JOURNAL
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THE CREATION*

BY H. GRAYSON-SMITH

FROM the earliest times man has speculated upon his own origin and the origin of the world around him. In all the ancient religions the stories of Creation are based upon the metaphysical principle that every effect must have a cause, although the cause might have no relation whatever to any logical deduction or natural law. Proper conceptions of infinity in space and eternity in time are quite modern. To the ancients the world was finite. It existed; therefore it must have been created; so it must have had a Creator, who was the great fundamental Cause. In reflecting upon the earth and the heavenly bodies they had very few facts to build upon, and they were perfectly free to indulge their imaginations to an unlimited extent. Some of the resulting "cosmogonies" were perfectly fantastic. In one Indian conception the principle of cause and effect is carried to an ultimate absurdity. The world is pictured as an inverted bowl, supporting the sky as a huge umbrella. The earth rests on the backs of four elephants; the elephants stand on a giant turtle; the turtle sits on the coils of a snake; and the snake supports himself by raising his head over all, and taking his tail in his mouth! In contrast to fantastic myths we have Genesis, so simple, and so beautifully expressed that we can find little fault with it to-day. But the simple belief in God the Creator left the speculative philosopher plenty of scope to use his

*Presented to the Edmonton Centre of the Royal Astronomical Society of Canada, February 8, 1951.

imagination in filling in the details, and there are Mediaeval Christian pictures almost as fantastic as the Indian.

The great speculation still goes on to-day, but with a profound difference. There are abundant facts of observation to build upon, and the cosmologist is restricted by having to make his picture agree with the facts, and, if possible, conform to known physical laws. The principle of cause and effect still holds, but also with a difference. To paraphrase a remark by the late R. C. Tolman, there is no reason to suppose that what merely exists might not have existed from eternity. We can say only that what is known to be evolving in one direction must have had a beginning. As long as we can trace it back by the use of natural law, or by logical use of a reasonable hypothesis, we are making proper use of the principle of cause and effect in its modern form. But we still cannot conceive that there was nothing beyond the beginning, and modern cosmology does not prevent us from continuing to believe in a Creator.

It was suggested above that the modern cosmologist is hampered by having to stick to the known facts, but hampered is hardly the word. Actually, the facts give him a new, and far more productive starting point. Writers of the last 50 years have drawn upon their imaginations in inventing hypotheses almost as freely as the ancients. Many of their ideas are far removed from the "scientific method" which, according to some, is to solve all the problems of the universe, and of man. Serious consideration is given to theories which are based on little more than a love of simplicity, and a delight in mathematical elegance. There is rejoicing when a prediction agrees with the facts within a factor of ten. And are these writers condemned by their colleagues for being "unscientific"? By no means. Their work is taken most seriously, and discussed at great length, for writers and critics alike realize that these speculations have great value, and that the limit of what can be explained by reasonable, logical theory is being steadily pushed back towards the "beginning of things." It is speculation, but it is intelligent and critical speculation, very different from the metaphysics and poetic myth of the ancients and of the Middle Ages.

In recent years every new discovery in astronomy or in physics which might throw light upon the nature of the cosmos has led to a new flood of papers, and some of these are still fundamental to-day.

For example, the first important series followed Einstein's epoch-making general laws of relativity and gravitation in 1915. But at that time there were still not nearly enough observational facts, and most of the papers concerned the possible forms which the framework of space-time might take. Mathematical methods developed in the years following Einstein still form the cosmologists' most important tool. Another flood followed the observations of Kapteyn, Shapley, J. S. Plaskett, about 1925-29, on the dimensions and rotation of the local galaxy. For it then became possible to talk with meaning and confidence about other galaxies, about the spatial extent of the universe of all galaxies, and about the average density of matter in space. The next and perhaps the greatest burst of activity in cosmology followed Hubble's announcement, in 1936, of the relation between the Doppler shift in the spectra of the distant nebulae, and the distance from the local system. This led to the ideas of the "Expanding Universe," with all that that implies. However, the discussion was dying down, for lack of new material to work upon, until just the last three years.

The new material which has brought about the recent renewal of interest is at the other extreme of the scale of dimensions, the scale of atomic nuclei. It lies in a reasonably good understanding of the reactions between nuclei, and especially of the conditions under which one element can be transformed into another, or even of the possibilities of the conversion of high energy radiation into matter. For the first time it has become possible to speculate intelligently about the very formation of the matter now in the universe. This is "Creation", and it is this feature of the newest cosmogonies that forms the main subject of this paper.

We must review briefly the most important of the observed facts upon which the new cosmological theories have to be built:

The main features of the universe of galaxies: The sun is located near the edge of the local galaxy—the Milky Way system—which is a spiral nebula about 30,000 light-years in diameter. The local galaxy is only one of millions of similar star systems, spread out in space as far as they can be observed with the largest telescope. The external galaxies differ in detail, but the average is about 10,000 light-years in diameter, and has a mass equal to about 10^8 suns. This might be taken to mean 10^8 actual stars, but a great part of

the mass is clearly in the form of diffuse clouds of dust and gas. The stars must have formed by condensations of this diffuse matter, and in a great many of the typical spirals, including our own, recent observations suggest that the central portions may never have condensed into stars at all. The average density of matter within a galaxy is about 10^{-24} gm. per c.c., equivalent to about one H-atom per c.c.

The distribution of galaxies in space: From counts of the numbers seen in the 100-inch telescope in typical regions, Hubble has estimated that there are about 10^9 galaxies down to the faintest which can be photographed with that instrument. As far as it is possible to tell at present, a statistical study of their apparent magnitudes indicates that they are uniformly distributed in space (apart from purely local clustering) out to a distance of at least 5×10^8 light-years, with an average separation of about 1,200,000 light-years.

The "red-shift" in the spectra of distant galaxies: In 1936 Hubble announced his famous discovery that the lines in the spectra of distant spiral nebulae are shifted towards the red by an amount $\Delta\lambda$ which is proportional to the apparent distance. The simplest explanation, accepted by most cosmologists, is that this is a Doppler effect, and is evidence of an actual recession, with velocity given by

$$v/c = \Delta\lambda/\lambda = 5.4 \times 10^{-10}\, r,$$

where c is the velocity of light, and r is the distance in light-years. It is sometimes hard to visualize just what this "expanding universe" means. It suggests to most people a picture in which our own local galaxy is at the centre, with all others flying away from it. But this is quite erroneous. We have no evidence that our galaxy is at the centre, and exactly the same observation must be made from any other galaxy. Hubble's observation means that the average distance between the galaxies is increasing at a uniform rate, as the mean distance between molecules would increase in an expanding gas.

The age of the universe: Here we must be careful to be quite sure what we mean, for we really have no evidence concerning the age of the universe as a whole. We can only discuss the time elapsed since some epoch-making event of which we have definite

evidence (Tolman). Remembering this, the latest figures will be quoted without discussion of the evidence. The earth is stated with considerable confidence to be 3.3×10^9 years old. The group of stars within a few thousand light-years of the sun is a bit older, say 5×10^9 years, but certainly not more than 7×10^9. The latter figure is taken by some writers to be the "age of the universe", but there is good reason to be more specific, and to accept this figure only for the age of the local galaxy. Other galaxies may be older or younger—there is no real evidence.

The conversion of hydrogen into helium within the stars, with production of energy equal to c^2 times the loss of mass, according to Einstein's mass-energy relation: It was long ago suggested that this process might be the origin of the tremendous quantity of energy which a star produces during its lifetime. Since 1945 it has been fairly well understood just how the process takes place, and the tremendous temperatures and pressures in the interior of a star do provide just the right conditions for the hydrogen-helium conversion.

At this point we might notice that these last three processes are all evidence of irreversible evolution, and so we are justified in applying the limited principle of cause and effect—what is known to be evolving must have had a beginning.

The relative abundance of the different chemical elements: In spite of the fact that the hydrogen-helium reaction has been going on within the stars of the local galaxy for some 5×10^9 years, recent observations show that hydrogen is still by far the most abundant element in the galaxy as a whole. The proportion of helium and heavier atoms to hydrogen atoms has been variously estimated at 1 to 15 per cent., with the weight of evidence in favour of the lower figure. But the relative abundance of heavy elements among themselves, of which the earth and the atmosphere of the sun are apparently fair samples, is also important evidence concerning the place and time when they were formed.

The overall mean density of matter in the universe of galaxies: This very important figure is still, unfortunately, rather uncertain. If, as was supposed until quite recently, nearly all the matter of the universe is concentrated in the galaxies, the figure may be as low as 10^{-30} gm. per c.c. However, it is now known that the light

from distant galaxies is slightly reddened (a different matter from the red-shift of the spectrum lines). A reasonable explanation is that the blue light is scattered by a very diffuse distribution of dust throughout the cosmos. If this dust is accompanied by the same proportion of hydrogen gas as we find within our own galaxy, the overall density may be as high as 10^{-27} gm. per c.c. Perhaps a fair estimate is between 1 and 5 times 10^{-28} gm. per c.c. This would mean about 100 atoms per cubic metre.

It will be noticed that several suppositions have already found their way into this summary of the "facts" upon which a new cosmology should be built. However, in every case the deduction from the observations is in accordance with well established physical principles. It is true that other explanations of some of the phenomena, for example, of the "red-shift," have been offered from time to time. But so far these special explanations have seemed less reasonable than the more obvious deductions.

The most important mathematical tool in working out the details of any cosmological model is Einstein's theory of general relativity and gravitation, and this requires a little examination before we proceed. There is a popular impression that Einstein's theory requires a closed universe. That is, the framework of space-time into which the galaxies have to be fitted is itself of finite extent, so that lines which are apparently parallel eventually converge. Such a universe would naturally contain a finite total mass of matter. But this is not necessarily true. Einstein's equations are also compatible with a so-called hyperbolic space, of infinite extent, in which parallel lines diverge. It all depends on the mean density of matter, and on the little quantity Λ, the so-called "cosmological constant". In their simple form, Einstein's equations do not allow a static solution, that is, a space-time of constant dimensions. Einstein therefore put in an extra term, involving Λ, in order to make a static universe possible (remember that this was 20 years before the recession of the galaxies was discovered). This resulted in the finite universe which is popularly associated with the theory. The cosmological constant is significant only on the cosmic scale. It is much too small to have any effect on the results when the equations are applied to a solar system, or even to a single galaxy, and so its value cannot, at present, be determined from observation.

Cosmologists have always felt perfectly free, therefore, to introduce Λ into their theories.

At last we are ready to discuss two cosmogonies which have arisen in the last three years, and which deal, as no earlier theories were able to do, with the creation of matter itself. With regard to creation, however, they represent two diametrically opposed views. The somewhat earlier theory, developed mainly by G. Gamow and his school, assumes that the universe of galaxies originated in some kind of tremendous explosion, and that the pieces have been flying apart ever since. It is described technically as a "point source" theory. The later theory, which was developed into a complete form by F. Hoyle, and which has recently received much publicity, is a "continuous source" theory, and assumes that new matter is being created all the time. We can here only outline the two theories, having especial regard to the creation features.

The idea of a point source "explosion" was not original with Gamow. The fact of the recession of the galaxies clearly suggests that at one time all the matter now contained in the visible universe was concentrated into a cloud filling a comparatively small volume. Something then started it expanding. Eddington discussed this idea in some of his writings, and showed that at a certain stage in the expansion the originally diffuse cloud would become unstable, and would break up into smaller clouds of about the right size and mass to form the existing galaxies. Later, some at least of the matter in each galaxy would condense into separate stars.

There was no really critical examination of the idea until the laws of the reactions between atomic nuclei became known. Then Gamow took it up vigorously, and developed from it a theory of the formation of the elements. He supposed that the known universe started, at a definite date, from a highly condensed state with the tremendous temperature of something like 10^{12} degrees absolute. Under this condition the condensed universe would consist almost entirely of radiation, in the form of very short gamma-rays. What matter existed would be entirely in the form of neutrons, with perhaps a few protons, but the total mass of matter would be much less than the mass-equivalent (energy/c^2) of the radiation. To describe the composition of the universe at this stage Gamow revived an obsolete mediaeval word "ylem", meaning primordial

material. At first the expansion would be determined by the radiation, and would take place at approximately the velocity of light. With expansion the temperature would drop, and when the universe cooled to about 10^{10} degrees, nuclear reactions would be possible, and chemical elements would begin to form from the ylem. The temperature, density, and proportion of different elements at any stage of the process can be calculated by the use of known physical laws. The extraordinary result is that all the atoms now in the universe would have been formed in about one hour! By then the temperature would be too low for further nuclear reactions to take place. It is virtually an instantaneous creation! But, of course, Gamow did not suggest where the ylem came from, or what started the expansion.

Galaxies would begin to form when the overall density was about equal to the present density of the local galaxy, at age about 100 million years. This may seem like a healthy age, but is really very early in the history of the visible universe. A little later the outer portions at least of each galactic cloud would condense into stars. Some time later still, the planets of the solar system could have formed (according to the process shown by von Weizsäcker to be possible) out of some scraps left behind when the sun contracted, or possibly thrown out from the sun by tidal forces when it was much larger than it is at present.

Gamow's theory of an almost instantaneous creation appeals strongly to one's sense of the fitness of things, and it is surprising that it did not receive more popular acclaim. As an intelligent speculation, a strong point in its favour is that formation from the ylem at a very early stage accounts very satisfactorily for the known relative abundance of the chemical elements. But there is one serious flaw, which is probably fatal to the whole theory. Gamow's universe turns out to be only about half as old as the known age of the earth!

The "age of the universe" according to Gamow's theory is determined from the rate of recession of the distant galaxies—the present rate of expansion. At the time the theory was first propounded the only accurate figure for the age of the earth itself was that of the oldest accessible rocks. The two figures roughly agreed, and who could say that the rate of expansion had been constant, or

that the earth had not been born very early in the life of the local galaxy. But the earth is now known to be a good deal older than was formerly supposed—a thousand million or so years older than any still existing rock—to say nothing of the probable age of the local galaxy. Then calculation, on the basis of Einstein's theory of gravitation, showed that the early stages of the expansion would have been faster, not slower, than the present rate.

The discrepancy in age is now quite definite, and can only be removed by a rather artificial adjustment of the theory, which involves the cosmological constant Λ. In a later version Gamow has tried to make such adjustments, but the arguments are not very convincing, and other difficulties creep in which we have no space to discuss. Rather reluctantly we have to abandon instantaneous creation, and see if some other hypothesis will not fit the facts better.

The obvious suggestion that the observed expansion is only the present phase of an alternate expansion and contraction is ruled out by the fact that the visible galaxies are not nearly old enough. If we have to accept a one-way evolution, and if the highly condensed primordial state of any "point source" theory is ruled out by the discrepancy in ages, the alternative is "continuous creation." This conception, discussed tentatively by several writers, forms the basis of the newest cosmogony of all, that which has reached its fullest development in the hands of F. Hoyle. The basic hypothesis is that, as the galaxies become more widely separated, new matter is created everywhere in intergalactic space, just enough to keep the overall density constant. Assuming that the created matter consists of hydrogen atoms, it requires only about ten new atoms per cubic mile per day (10^{-43} gm. per c.c. per sec.) to keep the universe going. Such an amount is hopelessly undetectable by any known means. Hoyle's creation is a far more radical idea than Gamow's. Gamow at least had an ylem of radiation and neutrons to start with. Hoyle's new atoms just appear—apparently out of nothing! This seems to violate one of the most cherished principles of physics, the conservation of mass-energy. However, physicists will be willing to modify that principle, by an undetectable amount, if the need is clearly indicated.

A strong point in the new cosmogony is that there is no need for the cosmological constant Λ, and we can dispose of it in the most

satisfactory manner possible, by throwing it away. It must be emphasized that this is a valid argument. It is a metaphysical belief, which can never be proved, that the fundamental laws of nature are simple in form, and from the time of Isaac Newton this principle has guided scientists to great fundamental discoveries. If Λ is discarded, the form of space-time can be calculated, knowing the mean density of matter, the rate of expansion, and the rate of creation. It turns out to be the divergent hyperbolic space of de Sitter, rather than the closed finite space of some of Einstein's writings. Hoyle therefore pictures the universe as infinite in extent, and eternal in time, but continually expanding. The term "age of the universe" no longer has any meaning.

Any attempt at a complete cosmogony must account for the organization of the visible universe, galaxies, stars, the solar system, and Hoyle has discussed much more than the creation of matter. Here we can only mention a few of the other features of the theory. The first step after the creation of matter must be aggregation into galaxies. Hoyle supposes that much of the newly created matter is swept up and drawn into the existing galaxies, so that the galaxies slowly grow. Once in a while a local irregularity in density begins to form into a definite cloud, and a new galaxy is born, so that the average number in a very large volume remains constant. On this theory we expect to find galaxies of all ages. It is true that galaxies of many different forms are known, and these may represent different stages of development and different ages, but none of those close enough to study their structure is clearly very young, or clearly very old. There ought to be plenty of young ones, and we can only suppose that they have to attain to a respectable age before they are recognizable as definite galaxies.

The apparent absence of very old galaxies follows naturally from an interesting feature of the theory. No matter how powerful we make our telescopes we can never see into space farther than 1.8×10^9 light-years. At that distance the velocity of recession becomes greater than the velocity of light, and no light from beyond can ever reach us. Since it would take a galaxy about 14×10^9 years to recede to that distance in the course of the general expansion, anything older has simply vanished beyond the visible limit. This idea may be difficult, because we are accustomed to

the statement, based on relativity theory, that no massive body can travel faster than light. But the statement means only that no system of forces, gravitational or electrical, can cause a body to move faster than light. The expansion of the universe is a different matter. It depends on the expansion of the space-time framework itself, and nothing of the nature of a repulsive force is involved, so relative velocities greater than that of light are possible at great enough distances.

We shall leave the questions of the formation and history of stars and of the solar system, and mention briefly only one other point. The formation of the heavy elements, which seemed to be so nicely explained by Gamow's point-source theory, presents a minor difficulty on the continuous creation theory. In Hoyle's universe the only place where conditions are suitable for nuclear reactions to build heavy elements is the interior of a star, and discrete stars do not occur until some time after the creation of the matter within them. Hoyle has to suppose that the heavy elements which are known to occur in the form of clouds of cosmic dust, as well as widely distributed sodium and calcium, are the debris of supernova outbursts. Supernovae, in turn, are considered to be the result of the collapse and eventual explosion of very hot stars which have burned up all their hydrogen much more rapidly than normal—a quite plausible explanation.

What of the future of cosmology? Hoyle certainly seems to have the best of it at the moment. The hypothesis of an infinite universe with continuous creation satisfies the principle of simplicity in natural law, and leads logically to an explanation of most of the observed facts. Other facts can be brought into line with it by adding a few quite reasonable assumptions, something which every cosmologist has had to do. But it would be very rash to say that it is the last word, or that it has yet been raised from the realm of intelligent speculation to that of confirmed theory. The present need is for more observation, and great things are expected from the new 200-inch telescope at Mount Palomar, as soon as there is time to collect and organize the data. Does the apparently uniform distribution of galaxies extend beyond the present limit of observation? Can effects due to the curvature of space—divergent or convergent—be observed? These questions are a little beyond the

limit of older telescopes; the 200-inch may provide an answer. Observation of the most distant galaxies may allow us to estimate the density of intergalactic matter, and fix the still uncertain figure for the overall density of the universe. We need badly a criterion for determining the ages of galaxies outside our own, and study of the details of moderately distant ones may provide it. This item of information would be decisive. If the universe expanded from one point source the nearby galaxies should all be the same age; very distant ones should look younger because of the time required for their light to reach us. If creation is continuous, galaxies of all ages should be found at all distances. Perhaps we can even find some of the clouds which ought to exist as the primitive stages of new galaxies. .

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CIRCULAR POLARIZATION OF 10.7-CENTIMETRE SOLAR NOISE BURSTS

By A. E. Covington

(With Plate VI)

ABSTRACT

During solar noise bursts on a wave-length of 10.7 centimetres, the intensities of the right-handed and left-handed circularly polarized radiations have been recorded. The more intense bursts can be grouped according to whether the intensities of the right-handed and the left-handed components are: (1) equal, or (2) unequal, or (3) whether only one component alone is present. When only one component is recorded, the radiation is circularly polarized.

A series of observations to detect circularly polarized solar radiations on a wave-length of 10.7 centimetres has been made in Ottawa at the laboratories of the National Research Council. This investigation was undertaken by placing the microwave counterpart of an optical quarter-wave plate in front of the four-foot paraboloidal reflector (see figure 1, pl. VI) which is regularly used to observe the solar radiation.[1] The quarter-wave "plate" is constructed from metallic strips and is so proportioned that two incident waves, plane polarized in perpendicular directions have a phase difference of 90° upon emerging from the plate. This property of the plate changes a circularly polarized wave into a linearly polarized wave (see figure 2). Waves of one sense of circular rotation emerge as a linear polarization with a definite plane of polarization in relation to the quarter-wave plate; waves of the opposite sense of rotation have the plane of polarization rotated through 90°. The dipole which is at the focus of the paraboloidal reflector can thus be rotated into a position which permits the reception of only one kind of circularly polarized radiation. Some energy from the other polarization is introduced from imperfections of various origins. Tests have shown that about two per cent. of the undesired energy will be present if the incident radiation contains both the desired and undesired polarizations in equal intensities. At a fixed instant of time a right-handed sense of

[1]A. E. Covington, *Proc. I. R. E.*, vol. 36, p. 454, 1948.
[2]A. E. Covington, *Proc. I. R. E.*, vol. 37, p. 407, 1949.

rotation is defined as a clockwise rotation of the electric field when viewed in the direction of propagation.

In the first series of experiments, during June, July and August 1948, the dipole was manually oriented in each of the two positions which allowed the reception of the two types of circularly polarized waves. The daily values of right-handed and left-handed radiations were observed, and the ratio of right-handed to left-handed

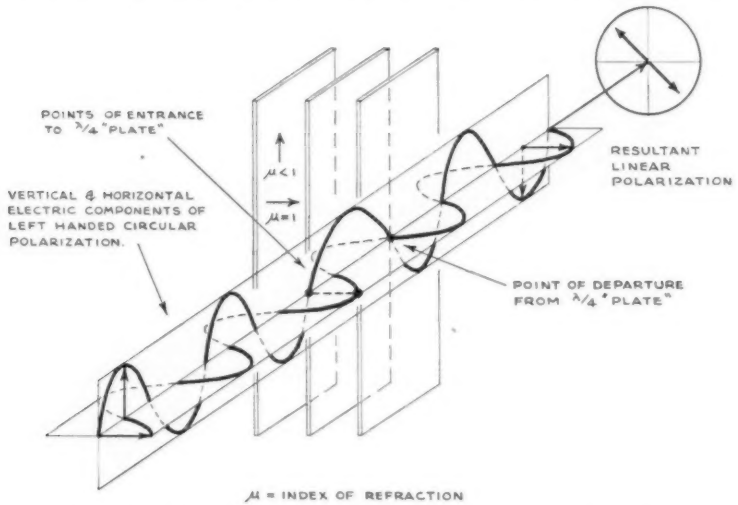
POINTS OF ENTRANCE TO λ/4 "PLATE"
VERTICAL & HORIZONTAL ELECTRIC COMPONENTS OF LEFT HANDED CIRCULAR POLARIZATION.
μ<1
μ=1
RESULTANT LINEAR POLARIZATION
POINT OF DEPARTURE FROM λ/4 "PLATE"
μ = INDEX OF REFRACTION

FIG. 2. — Circularly polarized wave train passing through quarter-wave plate.

components was plotted.[2] Significant changes in this ratio can be related to the appearance and disappearance of two large sun-spot groups and suggest that the spots emit circularly polarized waves. The radiation from the spotless sun was randomly polarized.

In order to examine the polarization of the short-lived and infrequent bursts of solar noise, the second series of experiments was conducted, during the summer of 1950. A continuous and rapid scanning for the two types of polarization was achieved by operating the dipole by a motor-driven cam, which placed the dipole in each of the two positions for twenty-five seconds, and rotated the dipole

from one position to the other during five seconds. Thus the intensity of the right- and left-handed circularly polarized waves could be measured every minute.

The results of the latter experiments are shown in Table I. In bursts of small intensity, a difference in the intensity of the two components is masked by the residual noise of the radiometer, or by possible small errors introduced through various imperfections

TABLE I

1950	Indeterminate Polarization		Circularly Polarized Radiation			Hours of Observation
	Bursts of Small Intensity	Bursts in Sunset	RH and LH Components of Equal Intensity	RH and LH Components of Unequal Intensity	Either RH or LH Component Alone	
May	9	1	2	2	0	140
June	6	1	1	1	0	185
July	2	1	1	0	1	130
Aug.	5	1	0	1	0	170
Totals	22	4	4	4	1	625

of the system. A few bursts are of short duration in relation to the scanning rate, so that it is impossible to obtain a difference in the intensities of the two polarizations. Since these bursts usually have a small intensity, they are grouped with the bursts of small intensity and long duration. Those bursts in which it is impossible to recognize a distinct difference of polarization have been placed in the column under "Indeterminate Polarization." Bursts which occur just before sunset are also placed in this column, since it is difficult to determine a difference in intensity of the two polarizations in the presence of interference between the direct solar ray, and the indirect solar ray which is reflected from the earth.

The intensities of the two polarizations can be clearly recognized in the remaining bursts. In one group the intensities of the right-handed and left-handed components are equal for the whole burst duration. Any difference in the intensity of the two components

is less than 10 per cent. In a second group, the intensities of the two components are of varying amounts. A good example of a burst in this class is shown in figure 3. In a third class, only one component was present for the whole burst duration. The intensity of the weaker component is less than 10 per cent. of the intensity of the stronger component.

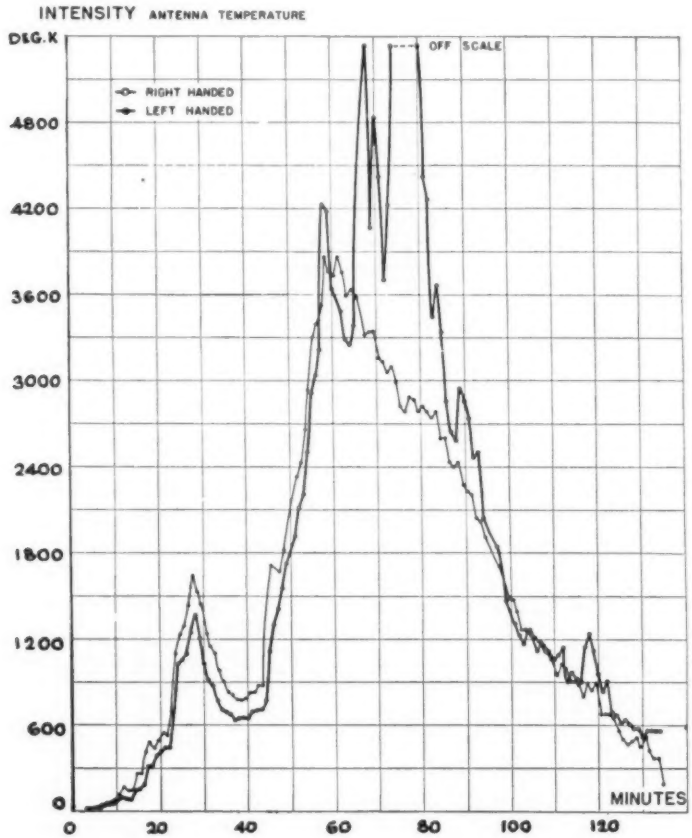

FIG. 3a. — Variation of circularly polarized radiation during the solar noise burst of May 26, 1950.

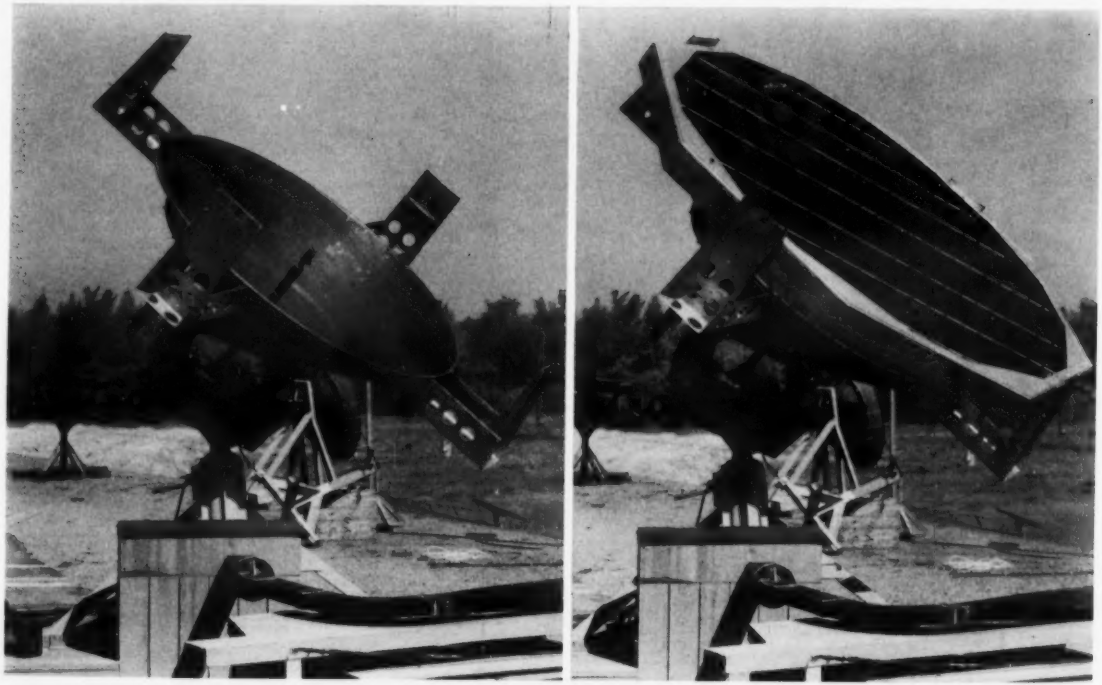

FIG. 1. — Radio-telescope constructed from a four-foot paraboloidal reflector: *left*, without quarter-wave plate; *right*, with quarter-wave plate.

Journal of the Royal Astronomical Society of Canada, 1951

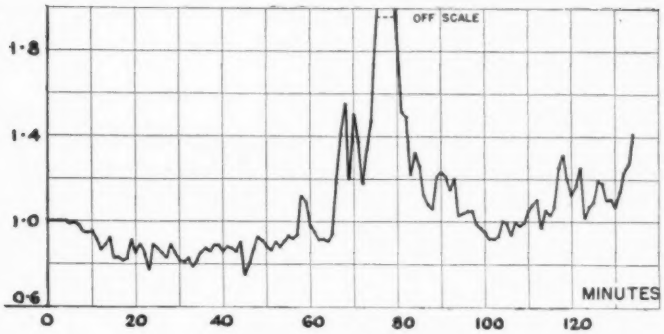

FIG. 3b. — Ratio of right-handed to left-handed solar radiation.

The observations taken with the quarter-wave plate alone are not quite sufficient to determine completely the polarization of the solar radiation. Additional observations to search simultaneously for the existence of a linear polarization are required in certain cases. For those bursts with equal components of right-handed and left-handed intensity, no distinction can be made between radiation linearly polarized in a certain fixed direction of space in relation to the quarter-wave plate, and between a random polarization. However, during an extended period of observation it is unlikely that all the bursts would have linearly polarized radiation with a definite plane of polarization in relation to the quarter-wave plate; so it may be reasonable to assume that the radiation is randomly polarized. Those bursts in which the two components are of unequal intensity are partially circularly polarized. The burst in which there is only one component is circularly polarized. This unique burst occurred on July 28, 1950, at 17 h. 35 m. G.M.T., and was not associated with any sudden ionospheric disturbance.

The author is pleased to acknowledge the assistance given by the personnel associated with this project. Mr. W. A. G. Kennedy has executed the mechanical design of the various components upon which so much depends.

National Research Council,
Ottawa, Ontario,
January, 1951.

MICROHARDNESS TESTING OF IRON METEORITES
(Concluded)

By F. K. Dalton

WHILE the procedure of microhardness testing and some typical measurements on meteorites have been described in earlier issues of this JOURNAL,* there are a few further deductions, and information on various inclusion materials to be recorded in order to complete the report on the first studies of iron meteorites by this new method.

OCTAHEDRITES

The discovery of soft taenite borders in the octahedrites of Canyon Diablo, Arizona, and Bristol, Tennessee, was one of the most surprising and most important results in this investigation. From the correlation of test data (figure 17, this JOURNAL, vol. 44, p. 192, 1950) the soft taenite has a lower nickel content than the harder taenite borders and, in the fine octahedrites from Bristol, it appears that the borders have even lower nickel content than the basic kamacite plates of these and other octahedrites. This relation is definitely at variance with, and actually contradicting some statements in several published articles and text-books wherein it appears to have been concluded in the past that taenite borders always have a higher nickel content than the kamacite plates in the same octahedrites.

In discussing the correlation of test data previously, the writer stated that the change in relative hardness of taenite from coarse, through medium, to fine octahedrites seemed to follow a sequence, a rule as indicated by the specimens tested in this investigation. To continue this discussion, and to show this relation more clearly, part of the graphs of nickel alpha iron and nickel gamma iron, from figure 17, have been replotted in figure 19, herewith, and connecting directive lines between kamacite and taenite values are added to emphasize the relation in both hardness and nickel content in the different classifications of octahedrites.

Taking coarse, medium and fine octahedrites having a kamacite

*R.A.S.C., *Journal*, vol. 44, pp. 1, 185, 1950.

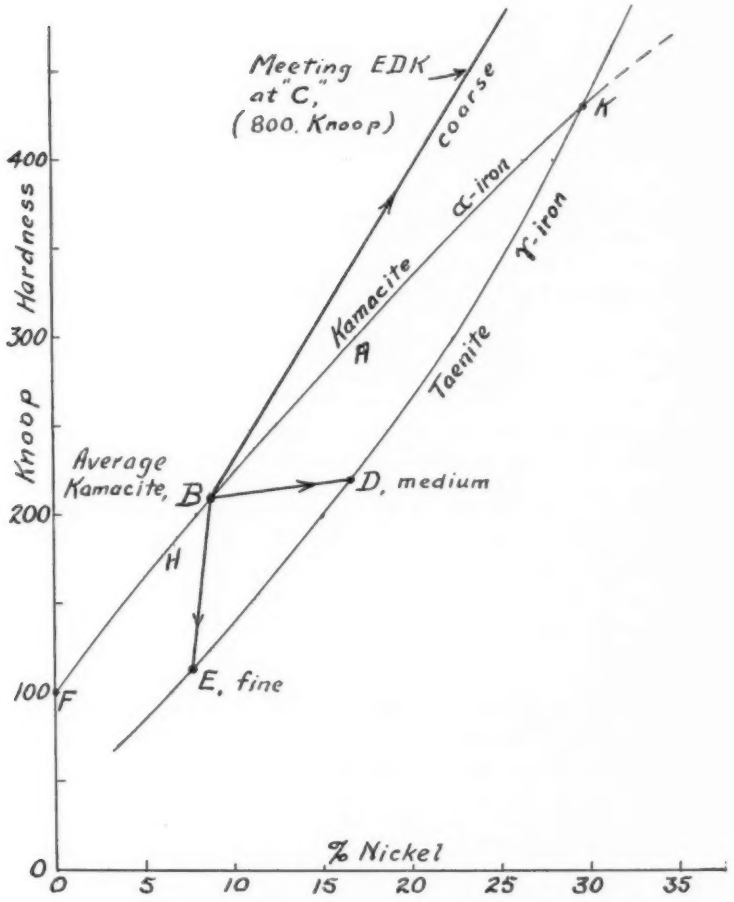

FIG. 19.—Kamacite-Taenite Relations in Octahedrites—showing differences for coarse, medium and fine Widmanstätten pattern.

hardness of about 210 Knoop, this common value is indicated by the point, *B* on the kamacite line, *FHAK*. In the coarse octahedrites tested, the taenite was comparatively hard, especially in the thicker borders, having hardness of about 800 Knoop, namely, at the point *C* which would be on the taenite line, *EDK*, projected. The straight line, *BC*, now indicates, by its inclination, that the difference in hardness between taenite and kamacite is very high in relation to the difference in nickel content in the coarse octahedrites represented.

For the medium octahedrites, the difference in hardness is small, and may even be negligible, as shown by the line *BD*, but the tests and the graphs still show a large difference in nickel content between taenite and kamacite, i.e. the horizontal component of the line *BD*.

Considering now the fine octahedrite, the line *BE*, a remarkable relation is observed—a striking difference in hardness—the taenite being much softer than the kamacite, with little difference in nickel content and even, as indicated, a lower nickel percentage in the taenite borders than in the basic kamacite plates.

Whereas the kamacite line, *FHAK*, terminates, at the left, at the hardness value of pure alpha iron, *F*, the taenite line, *KDE*, is directed further downwards, towards the origin of the graphs. This suggests that still lower nickel content may be expected in the taenite of finest octahedrites, the type with the narrowest borders, so something of further interest is anticipated when an opportunity is found to test these specimens of extremely fine Widmanstätten pattern.

When one considers the fine and finest octahedrites, and the statements made in published reports that not only are the kamacite plates narrower but that the taenite borders are wider than in the medium and coarse types, he is inclined to wonder if there is some confusion here. This reversal of hardness relations between kamacite and taenite in the fine varieties, the softer taenite with apparently lower nickel content than the kamacite, may have been misinterpreted by mistaking the kamacite for the taenite, and vice versa, in these meteorites. However, the resistance to etching proves that the soft border material definitely is taenite, not kamacite.

Non-Metallic Inclusions

Although it was the topaz-hard inclusions in Canyon Diablo meteorites, figure 20, that caused this investigation to be started, very little information has been obtained on these and other non-metallic materials found in iron meteorites as the studies have been limited to the metallic components. However, a few test results

Fig. 20.—Canyon Diablo Octahedrite, coarse—showing extremely hard inclusions of schreibersite and cohenite (black areas) which aroused the writer's curiosity resulting in this meteorite investigation.

on the three most common inclusions are given in the following notes.

Schreibersite—nickel iron phosphide; a tin white, ductile material which tarnishes quickly to a bronze yellow. Knoop hardness: 1100–1220.

Cohenite—nickel cobalt iron carbide (found chiefly in coarse octahedrites); a silver white, brittle substance which tarnishes to a bronze yellow or brown. Knoop hardness: 950–1360.

Troilite—iron sulphide or pyrrhotite (abundant in iron meteorites); a bronze or black material, slightly softer than kamacites. Knoop hardness: 190–200.

It will be observed that schreibersite and cohenite are about the same in colour, before and after tarnishing, and both resist action by the usual etchants. Knoop tests, therefore, may be useful as a means of identifying these two inclusion materials, or of differentiating between them. The hardness values of both of these ma-

terials, in Canyon Diablo meteorites, were proven to be very much higher than previous knowledge had indicated.

For the purpose of comparison, the Knoop hardness of three common rock materials will be of interest, as follows:

Topaz—1250.
Quartz—710–790.
Orthoclase (Feldspar)—560.

There are other non-metallic materials, found as inclusions in iron meteorites, but these were not tested in this investigation:

Moissanite—silicon carbide, natural carborundum; its physical and chemical properties agree with those of artificially produced carborundum.

Daubréelite—iron chromium sulphide; black material with metallic lustre, common in cubic iron meteorites.

Chromite—iron chromium oxide; black to brown, sometimes present, very common in stony meteorites.

Carbonadoes—black diamonds, amorphous carbon; very hard, inclined to crumble. When present, these are a serious handicap in polishing specimens, breaking up and causing deep grooves across the surfaces.

Conclusion

The most important conclusions from the microhardness tests on meteorites are already given in the previous articles but attention may again be drawn to the new method of study which has now been developed, and its advantages in making measurements in minute areas. It is necessary, however, that the specimens be very highly polished in order to insure accurate and consistent results. The indentations are so small that the specimen is not damaged nor disfigured in any way by the test.

The writer recognizes his exceptional good fortune in having the strong support and willing co-operation of Dr. H. H. Nininger, Director of the American Meteorite Museum in Arizona, in supplying specimens, and of Mr. H. Thomasson, Director of the Metallurgical Laboratories of the Canadian Westinghouse Co. in Hamilton, Ontario, and his assistant, Miss Effie M. Henderson, in making the microhardness tests, and is indeed grateful for their assistance. In concluding these first studies, the writer realizes that the mysterious complex structures of many meteorites must yet be tested to fully confirm or to adjust the results now obtained.

THE JUNE MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY AT WASHINGTON, D.C.

By Ralph E. Williamson

WARM friendship and warm weather were equally in evidence when the American Astronomical Society held its eighty-fifth meeting on June 20-23, 1951, at Washington, D.C., with the National Bureau of Standards and the U.S. Naval Observatory as co-hosts.

Members and friends of the society were entertained at a number of events, including tea at the home of Director and Mrs. E. U. Condon, National Bureau of Standards, an open house at the U.S. Naval Observatory, and the society dinner at the Naval Observatory. A number of tours were open to the visitors, covering different aspects of the work of the Bureau, from ceramics to radio astronomy. Many also took advantage of the invitation to visit the U.S. Naval Academy in Annapolis. In addition to these more formal items, members of the staffs of both host institutions, and their families, were most obliging in helping guests find their way to many spots of scenic and historic interest in Washington and its environs.

In spite of these pleasant distractions, 59 papers were presented. Interest was so great that the chairmen were forced to exercise the difficult prerogative of curtailing the discussion on a number of papers. In addition to contributions from 25 institutions in the United States and Canada the list of papers included reports on work in Mexico, Puerto Rico, the Netherlands, and Egypt.

It is always a difficult thing to single out for mention a few papers but the writer took special note of the following, which he felt would be of interest to both amateur and professional astronomers.

Nereid, the outer satellite of Neptune, discovered by Kuiper in 1949, now has a satisfactory orbit, thanks to the work of Dr. G. Van Biesbroeck, of the Yerkes Observatory. This interesting little 19th-magnitude object moves in the most flattened ellipse of any known satellite; the eccentricity is 0.76. In contrast with Triton, Neptune's other satellite, which moves in a retrograde direction with a moderately high inclination to the ecliptic, Nereid has direct motion, and keeps quite close to the ecliptic.

The refraction of the earth's atmosphere is of interest both be-

cause of its importance for celestial navigation, and because of its connection with our understanding of the atmosphere itself. One fruitful method of studying refraction is to make observations where the effect is greatest—near the horizon, where it is approximately one-half degree. Mr. G. M. Clemence, of the U.S. Naval Observatory, reported on the observations of a number of skilled navigators, who found no significant discrepancy between the predictions of the best theory of refraction and their results. This is in striking contradiction to the findings of Dr. Charles H. Smiley, of the Ladd Observatory, Brown University, who, with a group of observers, has made an intensive study of the same phenomenon. One ventures to predict that from these apparently discordant results will come new knowledge of our atmosphere.

Those who are interested in the stars as members of our galaxy are coming to see many references to stellar populations of Type I and Type II. A sample of the stars near our own sun will be predominantly Type I. The stars in globular clusters, and near the centre of our galaxy have different characteristics of temperature and luminosity, and are referred to as Type II stars. It has been suggested certain stars in the sun's neighbourhood (the so-called high-velocity stars, which revolve about the galactic centre at a *slower* speed than most stars!) are also members of the Type II population. This matter was discussed in two papers. One, presented by Dr. Lyman Spitzer, director of the Princeton University Observatory, developed the theory of a mechanism to account for the differences in speed of the two groups. The other, given by Dr. Philip C. Keenan, of the Perkins Observatory, summarized observations made on the spectra of stars of high velocity. He found that the spectral peculiarities of these stars (which have been thought to be of Type II) show a constant gradation from the most abnormal to those which are essentially Type I. The conclusion seems to be that there is no simple way of telling from the spectrum of a star whether it is a Type I or a Type II star.

How much does a galaxy weigh? This difficult question has been under consideration by Dr. Thornton Page of the Yerkes Observatory, who gave a progress report on his work on this subject with the 82-inch reflector of the McDonald Observatory. The method of weighing a galaxy which he is using is analogous to the method of weighing a double star, by observing the orbital velocity of the stars.

However, the periods of revolution of a double galaxy (of which he has observed a large number) are so great that one cannot observe them throughout a complete period. It is necessary to make a statistical treatment of the observed radial velocities of the different components of the double galaxies, to overcome this difficulty. Dr. Page's results indicate that the galaxies are divided into two groups. About two-thirds of the galaxies which he has observed have a mass of about four thousand million solar masses; the others are about 30 times as heavy. It is interesting to note that measures of the mass of our own galaxy, made in quite a different way, would put it in the class of the "giant" galaxies.

March 25, 1951, is a date which may well be compared with the date on which Fraunhofer made his first observations of the lines in the solar spectrum. For on March 25, the first astronomical observation of a spectral line in the *radio* region of the spectrum was made. The observation, made by Dr. Harold I. Ewen, of Harvard University, was also made independently several weeks later at the Leiden Observatory, by a team under the direction of Dr. J. H. Oort and Dr. H. C. van de Hulst. The line, at a wave-length of 21 centimetres, is due to neutral hydrogen, and was observed to come from interstellar space within our galaxy. It appeared as an emission line; that is, the radio emission at the 21-centimetre wave-length is slightly stronger than at wave-lengths both slightly longer and shorter. Although the observations reported at the meeting must be thought of as the very first attempts, they point the way to a number of important discoveries. By using radio telescopes tuned to this wave-length, for the first time, it will be possible to make a survey of our galaxy showing where neutral (rather than ionized) hydrogen exists in interstellar space. It is also possible to measure with high precision the line-of-sight velocity of the neutral hydrogen clouds, by the radio methods. Already, there is a strong indication that the rotation of the galaxy can be independently determined in this way. The preliminary observations have shown that hydrogen molecules are not abundant in interstellar space (if they were, the atomic hydrogen line would not be emitted), and it has been possible to measure the temperature of the neutral hydrogen in interstellar space. It is found to be about 40 degrees above absolute zero, in good agreement with theoretical calculations made by Dr. Lyman Spitzer. This is in interesting contrast to the temperature of the free electrons in interstellar space, which is about ten thousand degrees.

NOTES AND QUERIES

Fire at the David Dunlap Observatory

On May 16th a short circuit caused extensive fire damage in the wiring of the electrical panel on the lower floor of the large dome of the David Dunlap Observatory at Richmond Hill. The short circuit is believed to have occurred in the dome lighting circuit; heating was sufficient to ignite insulation of the wire, and this fire spread rapidly to the maze of wires leading from the panel. Mr. Gerald Longworth of the Observatory staff was in the dome at the time—a very fortunate circumstance, for otherwise there might have been serious damage to the telescope, not so much by the fire as by motion of the dome which was caused by accidental closing of the dome-turning circuit when the insulation had burned off wires which had sagged into contact from the heat. As it was, Mr. Longworth was able to cut off the power and extinguish the fire, but, in the few minutes between his first discovery of the fire and his extinguishing it, the insulation was burned from scores of wires leading from the panel to numerous electrical stations all over the dome. The replacing of these wires has amounted almost to re-wiring the dome, and has resulted in a loss of nearly four weeks observing time. In making the replacements the University electricians have made efforts to prevent a recurrence of this unfortunate accident.

J. F. H.

The ADH Telescope

In the January-February 1950 issue of the Journal the project of the Armagh-Dunsink-Harvard telescope was described. This telescope is now in operation at Bloemfontein, South Africa. It is erected at the Harvard Observatory's southern station, through international co-operation among the governments of Northern Ireland and Eire, and Harvard University.

This is the first large Baker-Schmidt type of telescope to be constructed. It employs a second mirror to produce a flat field and has a shorter tube length than the conventional Schmidt. The primary mirror is 36 inches in diameter; the secondary mirror 16 inches; the correcting plate 32 inches. The field covers an area of about 18 square

degrees (nearly equal to 100 full moons), and the stellar images are of excellent quality to the edge of the field. An objective prism, 33 inches in diameter with a five degree angle, will be used with the telescope. The optical figuring of the prism is now completed; the cell to house the prism is not yet finished.

The telescope arrived in South Africa from the shop of the Perkin-Elmer Corporation, Norwalk, Connecticut, in October 1950, and within two months was erected and put into operation under the guidance of Dr. John S. Paraskevopoulos, the resident superintendent of the station, and Dr. Bart J. Bok of Harvard Observatory.

The observing time with the telescope will be shared among the three observatories, Armagh, Dunsink and Harvard.

R. J. N.

The Asteroid Icarus

Two years ago Walter Baade, using the 48-inch Schmidt telescope of the Palomar Observatory, discovered this fast-moving object. Measures of the plates led Nicholson and Richardson to the conclusion that this asteroid was unusual in that at perihelion it passes inside the orbit of Mercury, closer to the sun than any other. It was subsequently named Icarus for the Greek youth who flew so close to the sun that it melted the wax with which his wings were attached to his body.

Recently new elements of the orbit have been published by Dr. Jorge Bobone of the Cordoba Observatory in Argentina. These differ slightly from the original values of Nicholson and Richardson. The new elements (from H.A.C. 1129) are as follows:

ω	30.°878		T	1950 June 7.267 G.C.T.
Ω	87.°770	1950.0	e	0.82667
i	22.°997		a	1.07784 A.U.
			P	408.72 days

The mean distance, a, just over one astronomical unit, is smaller than that of any other asteroid or comet. The eccentricity, e, being so large, brings the object at perihelion within 0.20 A.U., or about 19 million miles of the sun (perihelion distance of Mercury is 0.31 A.U.); at aphelion it recedes to 1.97 A.U., or about 183 million miles, and be-

yond the orbit of Mars. Because of the inclination of 23° of the orbit to the plane of the ecliptic, the asteroid will not collide with the earth; the closest approach is about 4 million miles.

This summer Icarus is again close to the sun in its orbit, being at perihelion on July 23, about 110 million miles from the earth. It is a faint object, no brighter than 15th magnitude. On this revolution it is closest to the earth early in August, but its magnitude then is 17.

The diameter, inferred from the apparent brightness, is a bit less than a mile. At its perihelion distance the estimated temperature of a non-rotating object with no atmosphere is nearly 1000°F., so that it might be hot enough to glow faintly. However, if the object is rotating the temperature would be considerably lower.

For many years it was thought that all asteroids were in the zone between Mars and Jupiter, and theories of the origin of the planets made use of this assumption. However, more and more asteroids are being found to exist closer to the sun. These fast-moving objects may be of importance in connection with the evolution of the solar system. Another way in which Icarus and other asteroids of this type may be important is in determining the mass of Mercury by observing its perturbations on the orbit of the asteroid.

R. J. N.

Death of Dr. Curvin H. Gingrich

Dr. Curvin H. Gingrich, professor of mathematics and astronomy at Carleton College, Northfield, Minnesota, and for twenty-five years editor of *Popular Astronomy*, died in Northfield on June 17, 1951, aged seventy. His association with Carleton College began in 1909 and during the course of years he has been acting dean, dean and assistant to the principal as well as carrying on his duties as professor of mathematics and astronomy. His connection with *Popular Astronomy* began a year later, with his appointment as assistant editor; he became editor in 1926. He was interested in the magnitudes, distances and proper motions of stars and in observing asteroids and comets.

In a letter from the associate editors, it is announced that a detailed account of Dr. Gingrich's career will appear in the August issue of *Popular Astronomy*.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Le Gentil and the Transits of Venus, 1761 and 1769

(*Concluded from May-June* Journal)

Le Gentil's despair at his unscheduled return to the Isle de France after the ship Indian had been damaged by a tempest, was heightened by the fact that he had great difficulty in getting passage on any other ship bound towards France. He had been assured passage on a French ship returning from China, but when the vessel arrived he was not allowed to embark on it, for no definite reason except apparently a hostility on the part of the French officials on the island. He states that this was the only disagreeable episode which he experienced in any of the colonies of France during his lengthy sojourns. In March 1771 however, a Spanish warship arrived, whose captain received Le Gentil most cordially, and it was on the Spanish frigate Astrée that Le Gentil was finally transported to Cadiz. Even on this ship, his passage around the Cape was not an easy one.

> I had planned to re-embark on one of the ships returning from China, which passed by the Isle de France on their return, arrived there in the first days of March and left again in the same period. I was assured on the word of the commissioner who had promised that he would get me a place on one of these ships, and who had repeated the same promise to me more than once. But in actual fact I could find no place on these ships under the pretext that they were loaded with special cargo and that they no longer belonged to the India Company. Finally I experienced here on the part of the government of the Isle de France exactly the same difficulties which had been made in Manila when I wanted to go to Acapulco in 1767. It seemed that at that moment the same spirit animated the Philippines and the Isle de France. There had been a time when M. Desforges was in command of this island, when all possible ways had been opened for me. There was, very happily for me, at the Isle de France, the Astrée, warship of his Catholic Majesty. This frigate was returning from Manila, and was commanded by Don Joseph of Cordova, captain of the frigate; I had known him on my voyage on the Bon Conseil. The Astrée arrived March 7th. . . .
>
> How impossible it is for me to find terms to depict the obliging air with which Don Joseph of Cordova received the proposition of M. de Modave [to take Le Gentil as a passenger], and to describe the pleasure which it appeared to give him. . . . As if Don Joseph of Cordova wanted to command a great ship solely from the desire of seeing me more comfortable there. . . .

Don Joseph of Cordova, with whom I dined on the 26th at the home of M. Estenaur, having assured me that he was leaving within two or three days, I had carried on board the greater portion of my belongings on the 27th. . . .

On the afternoon of the 29th I carried aboard the rest of my belongings, even my bed. I returned to land however to spend the evening with some of my friends, and I slept at the home of one of them. I trusted in the word which Don Joseph of Cordova gave me that in case he was leaving the next day he would warn me of it by a cannon shot.

Indeed, the next day, the morning of the 30th, at ten o'clock a loud cannon shot which I heard made me rush on board. It was in such haste that I left the Isle de France. . . .

We sailed March 30, 1771, and I left the Isle de France three months after my return on the Indian: at the time when I should, without the adventure of the tempest of Dec. 3, 1770, have been in France, or at least near its shores.

We found ourselves towards the end of April around the Cape of Good Hope where new troubles awaited me for we remained almost two weeks struggling before being able to round this cape. During this time we experienced tempests on tempests, some of which were almost as bad as those which I had seen on the Indian. My sole worry in the midst of all these storms was the fear of being forced to see again the Isle de France, that island which I had nevertheless loved very much; but the sight of it had become unbearable to me since the misfortunes which I had finally had to experience. I told Don Joseph of Cordova my worry about the bad weather which we were having; he assured me that he would go back only as a last resort. He was an excellent officer, very intelligent and very active. He kept his eye on everything: he had a great deal of confidence in his frigate which was indeed an excellent ship. I learned during this hard passage what a good ship well commanded can do on the sea. Our frigate carried twenty-six twelve-inch cannon, armed, the gun ports open, and with only our port lids. Thus we went around the Cape in the middle of the worst weather; the sea was horrible, as I had never before seen it; I admired how this little ship balanced in the middle of this frightful sea; we received only a single wave over us, which did not do us the least harm. We continually manoeuvred; I believe that more manoeuvres were made on board the Astrée during the two weeks in the seas of the Cape of Good Hope than I had seen made during six years of travel. . . .

At this point in his narrative Le Gentil gives an interesting description of the visibility of Canopus and Sirius before sunset. Most of Le Gentil's scientific observations were published in different memoirs of the French Academy of Sciences, and are not included in the two volumes of his "Voyage" from which we are quoting.

At the Banc des Eguilles, before the tempest of which I have just spoken, the sky was of the greatest transparency and I witnessed a phenomenon which had never been seen in France, at least as far as I know, even in the finest and

most serene weather. April 10th, when we were at 30 degrees 45 minutes of south latitude and about 16 degrees east of the Cape of Good Hope, a quarter of an hour before sunset, I perceived a star which was bordering upon the yard of the top gallant sail: I recognized that it was Canopus; then I looked for Sirius which I saw much more distinctly than Canopus. Indeed, Sirius in its splendour triumphs over this latter, and it is probable that I would have seen these stars still sooner if I had looked for them; but I did not know that they could be seen when the sun was above the horizon. I informed M. de Cordova and his office staff; they all saw, as I did, Canopus and Sirius before sunset. The night which came on resembled those beautiful nights of India of which I have spoken, and the stars had no twinkling.

After the Astrée had rounded the Cape, it met the French vessels on which Le Gentil had been refused passage, and acted as escort for them. There was also an interesting meeting with an English vessel, from whose captain Don Joseph extracted the information that England was not at war with Spain. This encounter ended happily when the English captain presented Don Joseph with the treat of a sack of potatoes. Le Gentil appears to condemn this latter with faint praise when he remarks, "At sea everything seems good."

Finally we went around this Cape quite luckily on May 11th: I say very luckily, to have come to the end of it without the slightest mishap, except for the loss of a great forestay which was carried off contrary to our expectations, because it was quite new and Don Joseph of Cordova had had it made expressly before arriving at the Cape to maintain us at the Cape.

When we had arrived at 11 degrees of north latitude and near the 36th meridian west of Paris, we met the French vessels from China on which I had not been able to embark at the Isle de France: they had left about ten days after us.

We had all left this island with news of the preparations of war between Spain, France and England: consequently the vessels from China which had forty-five millions of riches asked M. de Cordova to escort them as far as the neighbourhood of the tropics because they hoped to find there some ships which would give us news of Europe, the ships of England which are going to America going ordinarily as far as the tropic of Cancer. M. de Cordova answered quite obligingly to the captain of the Duras commanding the little division, "that he could not ask better than to escort them; but that he was afraid of making him lose some time because his frigate did not go as well as the two French vessels; however he would go as fast as he could". M. Dordelin commanding the Duras having agreed that he would suit his pace to that of the Astrée, we went together from June 11 until the 24th of the same month. That day, which was the second after we had left the tropics, we met an English vessel with three masts. We stopped it: the ship's boat was put to sea and sent to look for

the captain and the supercargo with an order to bring back the invoice of the ship. The English captain was not too sure what they wanted him to say: he did not imagine that we had come from so far and that we were as little informed about the affairs of Europe as we were. When he had arrived on board the Astrée Don Joseph of Cordova, the better to draw out from him the information we desired, declared to him that he was his prisoner "because he had", he told him, "met only two days ago a despatch boat from Spain which was carrying to America the news of the declaration of war between Spain and England." The English captain appeared much surprised at the statement: he answered "that he knew nothing of this news; that it was indeed true that there had been a great deal of preparation in England; that they had armed; but that on his departure they were busy in disarming because the differences which had arisen among the three powers, England, France, and Spain, were settled." He was asked if he could give us some proof of what he said. He offered to show us the London *Gazette* for which he sent from his ship, and in which we saw the truth of what he had told us. Don Joseph of Cordova had brought some Spanish wine of several kinds, some biscuits, macaroons, etc., and we drank to his bon voyage. Potatoes were, without doubt, in fashion in England as I found them in France when I arrived; for when the English captain had returned to his ship he sent us a great bag of them and butter in proportion. At sea everything seems good; this sort of refreshment gave us great pleasure.

The ships from China, better sailors than the Astrée, thanked Don Joseph of Cordova and left us.

The captain of one of these ships wrote me to ask me to go on to his ship. It was too late to profit from his offer, he had refused me at the Isle de France; Don Joseph of Cordova had on the contrary received me with a great deal of kindness; I had received from him until then all sorts of good treatment; was it possible for me not to recognize so great a service by abandoning my benefactor at the moment when we were reaching Cadiz? . . .

We were delayed still again by contrary winds for eight to ten days; this was after having passed the Azores. At last I arrived at Cadiz the first of August, four months and two days after having left the Isle de France.

Le Gentil, who lingered nearly a month at Cadiz to rest and escape the heat, describes his overland journey to France in some detail. He had left the Isle de France so precipitously that he had not procured piastres, and had only paper money with him, so he had to be indebted to his friends to furnish him with money in Spain. One of his great moments was his actual reentry into France on October 8, 1771.

The eighth, at sun rise, we passed the crest of the Pyrenees, and at last I set foot on France at nine o'clock in the morning, after eleven years, six months and thirteen days of absence.

Unfortunately several disagreeable episodes greeted his return. One was that his heirs and creditors, believing him dead, were all ready to divide his estate. Another was that his procurer had been careless in keeping the estate funds and had been robbed of a large sum, which loss, after an acrimonious court fight, Le Gentil had to suffer himself. Probably his most bitter reward was to learn that he had been superseded in the Academy of Sciences, on whose behalf he had undertaken the journeys! This last indignity was rectified on February 28, 1772, four months after his return, by a letter from the faithful Duc de la Vrilliere informing him that His Majesty begged him to take his place again in the Academy.

Le Gentil must have derived a certain amount of sardonic satisfaction from people's astonishment at his appearance in the flesh, when he was finally able to drive in his native region. He says,

> I was very well received by everybody; people went to their windows and doors when I passed through the streets, and I had many times the satisfaction of hearing people recognize me and attest loudly that I was really alive.

One of the most bitter disappointments of his voyage was the loss of his precious cases of natural history, to the number of eight. These had left the Isle de France with him on the vessel Indian on its ill-fated attempt to round the Cape. After the return of the vessel to the Isle de France Le Gentil was not able to locate the whereabouts of the cases. He spent much time after his arrival in France trying to trace them, but he never saw them again, even though people with diplomatic powers made vigorous efforts to discover what had happened to them.

A happier aspect of his return was his marriage to Mlle. Potier, of Cotentin; and the arrival of a daughter that he adored provided him with a happy family circle after his years of lonely wanderings. He spent much time in writing his memoirs and the papers from his expedition. He died from an illness he contracted in October 1792, and was thereby spared many of the horrors of the revolution. Cassini in the concluding paragraphs of his Eulogy (*op. cit.*) sums up Le Gentil's personality.

> A healthy constitution which the voyages had strengthened rather than weakened, exempted M. Le Gentil from any sickness and would have brought him a longer life if an acute illness had not carried him off in the month of October 1792. He was only sixty-seven years old; but death, by cutting his

life short like that, spared him at least the spectacle of the great storm which was going to break, and of the destruction of the Academy of Sciences which certainly would have troubled the peace and happiness which he prided himself on enjoying. His face did not prejudice one in his favour; but animated by conversation, it took on an expression of wit and of originality which was pleasing. In his sea voyages he had contracted a little unsociability and brusqueness, but without rudeness; because to his intimates he was gay, pleasant, and agreeable. Finally to finish picturing him we shall say that he was a good fellow member of the Academy, a very good husband, and an excellent father.

His place in the Academy was not filled. In 1793 it was no longer a question of naming persons to academies, people busied themselves in suppressing them.

Thus at the age of sixty-seven, death came to Le Gentil, whose zeal for astronomy had carried him on eleven years of voyages and absence from his native land. Contrary to the impression given by Flammarion in his volume "Popular Astronomy" (Gore's translation, 1894, page 233), his life did not end soon after his return to France, for he enjoyed twenty-one years of life there after his voyages.

In his attempts to observe the transits of Venus he has set a record for astronomical persistence which it would be hard to equal. Nowadays we have astronomical equipment and facilities of living which it would have been impossible even to imagine two centuries ago. We can hardly hope to surpass some of the early astronomers in zeal, however.

For some centuries now the transits of Venus have been occurring in pairs eight years apart, with more than a century between the pairs, and this will continue for some time to come. Before and after these long periods of pairs of transits, there are long intervals of time during which the transits occur singly with an interval of more than a hundred years between each one. It is unusual when, in a given century, no transit of Venus occurs, as happens in the twentieth century. The last pair of transits occurred on December 8, 1874, and December 6, 1882. Few of our JOURNAL readers at present will have the opportunity to see a pair of transits as the next pair will not occur till June 8, 2004, and June 6, 2012.

REVIEW OF PUBLICATIONS

Johannes Kepler: Life and Letters, by Carola Baumgardt, with an introduction by Albert Einstein. Pages 209, 5¾ × 9 in. Portrait and two facsimiles. New York: Philosophical Library, 15 East 40th St., 1951, $3.75.

This biography is built upon the voluminous correspondence of Kepler, and the graceful and scholarly translations by the author, with her useful footnotes, render the book easy and pleasant to read. The account of Kepler's scientific investigations gives a very modern feeling to them.

The evidence here brought forth reveals Kepler as the embodiment of truth and personal integrity. He was sure of his views on the Copernican theory and also of his protestant religious belief, and he always had the high respect of those who disagreed with him. He had many family and financial troubles, but his great ability and buoyant nature allowed him to surmount all obstacles.

As Imperial Mathematician at the court of Rudolph II in Prague, in succession to Tycho Brahe (1601), he reached the zenith of his career, but his salary was always in arrears.

Kepler received an invitation to go to England in 1620, but he could not make up his mind to leave Germany.

The long and strenuous fight to save his mother from death for sorcery is a thrilling story. She was actually imprisoned and taken to the torture chamber, but finally was acquitted.

The valuable introduction by Einstein will assist the reader to obtain an appreciation of the significance of Kepler's original researches.

C. A. C.

MEETINGS OF THE SOCIETY

AT WINNIPEG

May 9, 1951.—The regular meeting of the Society took the form of an Observation Night and, through the kind auspices of Mr. D. V. Pennock, was held at his home, 115 Hertford Boulevard, Tuxedo. There were about thirty members present.

Three telescopes were on hand—the Cooke Forage refractor as well as an excellent telescope of unknown make, and Mr. E. R. Gardner kindly lent us his hand-held Dolland two-inch scope for the evening. Conditions were ideal and Venus, Saturn and the Moon provided great interest to all the members.

After the meeting, the host and hostess provided the assemblage with most delicious buffet refreshments and it was generally accepted that this was one of the Society's most successful Observation nights.

A. J. VINCENT, *Secretary*

AT EDMONTON

January 11, 1951.—The meeting was called to order at 8:20 by the new President, Mr. Deane, who welcomed members and guests and outlined the organization of the society. There were 41 members and visitors present.

The main programme at the meeting consisted of films shown through the courtesy of Mr. Gads and the R.C.A.F. These were discussed briefly by a few remarks and were as follows:

(1) "Maps we live by", prepared for the United Nations Organization.
(2) "The impossible may", an amusing colour fantasy produced by the National Film Board of Canada.
(3) "Atomic Physics", Parts I, II, and III, produced by the film board of Great Britain.

This last film gave the historical background of the growth of atomic ideas from the time of Dalton up to the discovery of the neutron in 1932. It included some extracts from historical films and also some remarks by well known physicists like J. J. Thomson and Lord Rutherford.

February 8, 1951.—The meeting was called to order by the President at 8:20. There were 40 members and visitors present. Mr. Keeping reported that the two books recently added to the library were "Causes of Catastrophe" by D. Leet, and "Conquest of Space" by W. Ley.

The main paper was given by Dr. H. Grayson-Smith on "The Creation." Modern cosmology is still highly speculative, but it must be viewed as intelligent speculation, based on a wealth of observed facts, in contrast to some of the fantastic imaginations of the ancients. Different major discoveries of the last 50 years, some in physics and some in astronomy, have each led in their

turn to a flood of papers in cosmology. The latest revival interest, within the last three years, has followed an understanding by physicists of the conditions governing reactions between atomic nuclei. It is now possible to speculate intelligently about the very formation of the matter in the universe. This is Creation, and is the feature of the new theories with which this paper is mainly concerned.

The facts regarding a new cosmological theory include: The organization of the observable matter of the universe into galaxies; the apparent recession of distant galaxies, leading to the conception of an expanding universe; the consumption of hydrogen by the stars, showing that there is a one-way evolution; the age of the earth and of the local galaxy; the probable average density of matter throughout space.

Based upon these facts two main theories have recently been advanced, largely by G. Gamow and by F. Hoyle. These theories are diametrically opposed in their views of creation. In Gamow's theory it is supposed that the whole universe expanded from one primordial highly condensed cloud, of neutrons plus radiation. Calculation yields the amazing results that all existing matter would have been formed in the first hour, a virtually instantaneous creation. The universe as we know it, is finite in volume, and of finite age. Unfortunately, the calculated age of the universe is less than the known age of the earth, and rather artificial extra assumptions have to be made to remove the discrepancy.

Hoyle's theory describes an infinite universe, eternal in time, but continually expanding. As it expands new matter is continually created, everywhere in space, at a rate just sufficient to keep the average density constant. This radical hypothesis does explain the observed facts, with only a few quite reasonable assumptions, and at the moment Hoyle seems to have the best of the argument. The new atoms apparently are simply created out of nothing. Hoyle makes no attempt, therefore, to say what is behind his creation, but neither could Gamow say what was behind his primordial universe.

March 8, 1951.—The meeting was called to order at 8:18 p.m.; 31 members and visitors were present.

The main paper of the evening was given by Mr. S. A. Linstedt on "Planetaria". A simple training planetarium was built in the Education Building in 1943 by the speaker and Mr. Gads. Experience was also gained at an Astro link in Manitoba. The description of the Adler Planetarium in Chicago was given as typical of them all. The outside and inside of this planetarium were shown by projected pictures, and details of construction were given.

There are 32 projectors for fixed stars. There is a copper plate with 65 different sized holes for magnitudes as object which is focussed on dome. A mechanical eyelid keeps light from shining on the floor if star would be below the horizon. There can be rotation in four minutes around the polar axis. The holes in the copper plates are illuminated by a central 1000 watt bulb. There are separate projectors for Magellan Clouds and for Sirius. Variable stars have their own lamps as well as projectors. Separate projectors for flashing the

names of constellations on the dome. Milky Way needs a special cylindrical projector with film. Mercury eyelid acts between cylinders in this case.

Difficulties of showing the sun's uneven motion were explained and also the special mechanical difficulties for planets. An accuracy of one degree in 5000 years has been achieved. Extra difficulties are met in showing the moon and ingenious devices for showing phases have been developed. Other moving projectors show equator and ecliptic lines, fixed ones show zenith and meridian lines.

An outline was shown of seasonal variation in lecture topics which carried on a month at a time. Regular, and special features are given.

April 12, 1951.—The meeting was called to order at 8:20. There were 43 members and visitors present.

The main part of the programme consisted in the showing of Parts IV and V of the film on "Atomic Physics", through the courtesy of Mr. Gads and the R.C.A.F. This was followed by questions and some discussion on the general status of atomic physics.

May 10, 1951.—The meeting was called to order at 8:18 by the President. There were 28 members and visitors present.

The main paper was given by Dr. W. W. Happ on "Sir Arthur Eddington" Similar to Newton, Laplace or Einstein, it is true of Sir Arthur Eddington, that, had he never made a single contribution to astronomy, his work in other branches of science would still place him among the great of his time.

Eddington's major contribution to astronomy, physics, philosophy and—last but not least—to popularising science, were outlined. The basic ideas of his philosophy of 'structuralism' and 'selective subjectivism' were discussed and related to his investigation on cosmology that occupied nearly exclusively the last twenty years of his life. The results of his work are published posthumously as 'Fundamental Theory' and an attempt was made to show the impact of these theories on present day scientific and philosophical thought.

E. H. Gowan, *Honorary Secretary*

AT TORONTO

February 6, 1951.—The meeting was held in McLennan Physics Laboratory with the President, Mr. F. L. Troyer, in the chair.

Dr. J. F. Heard introduced the speaker, Mr. G. M. Clemence, head astronomer of the U.S. Naval Observatory at Washington and Director of the Nautical Almanac Office. Mr. Clemence spoke on "The Measure of Time".

It is not necessary to know philosophically what time is in order to measure it. Measurement methods are chosen for two chief characteristics—accessibility and invariability. The present fundamental unit is the mean solar day, although daily determinations are made from the transits of stars, and afterwards related to the solar standard.

At the Naval Observatory a photographic zenith tube is used for time determination. This instrument is rigidly fixed in a vertical position and photographs only those objects passing very near the zenith. The light from a star passes through a lens at the upper end of the instrument, is reflected from a mercury basin at the lower end and comes to a focus on a small photographic plate located just under the lens. The plate and lens can be rotated through 180°, and if this is done, the distance on the plate between images of the star, before and after reversal, corresponds to twice the zenith distance of the star. Were it possible to take two photographs in the same instant, when the star was exactly in the zenith, the two images would coincide, and the time of meridian transit would be the time the photograph was taken. In practice the plate is driven from west to east so as to keep pace with the motion of the star's image and the clock time at which the plate is in certain positions is recorded. The images obtained before and after reversal do not coincide, but by measurement of the distances of the images it is possible to determine the positions of the stars during the exposure, and to deduce the times of transit.

One intrinsic difficulty with time determination is variability in the earth's speed of rotation. There is a secular change due to slowing down by tidal friction. There are rotational changes, known as fluctuations, which are of unknown cause and non-periodic. Seasonal changes of the order of 0.06 sec. are experienced because of interchanges in moment of inertia of the earth and its atmosphere.

An invariable time standard is defined as one which shows the heavenly bodies to move according to the laws of gravitation. This favours the mean sidereal year as a fundamental standard of time, though it is at the present impractical for daily use.

The best clocks in practical use are quartz-crystal controlled. The crystal oscillates 100,000 times a second, and controls an electric current which is used to drive a synchronous motor clock movement. The clock rates and errors can be determined, and results are sufficiently accurate to show the seasonal variation in the earth's rotational speed. Research is being carried out upon clocks controlled by molecular vibrations, and in particular, upon an ammonia molecular clock, which when it can be made to run for an appreciable length of time, will be man's finest clock.

The speaker was thanked by Mr. A. R. Clute.

A resolution presented by Mr. Kennedy was passed, regarding the death of Mr. H. W. Barker.

February 20, 1950.—A Members' Night was held in the McLennan Physics Laboratory, the Chairman being Mr. F. L. Troyer, President.

Ten candidates were elected to membership in the Society. These were:

Frank Barnes, 490 Oakwood Ave., Toronto 10.

A. J. Gladstone Campbell, B.Sc., 477 Bayview Ave., Toronto 17.

Mrs. Mabel Harvey, 1 Warren Crescent, Toronto 9.

James H. Mucklow, R.R. No. 2, Pickering, Ont.

Kenneth O'Daiskey, 231 Wilma St., Sudbury, Ont.
Dudley A. Sherwood, B.Sc., 81 Harcourt Ave., Toronto 6.
Christopher E. Swallow, 280 Airdrie Rd., Toronto 17.
John Tomkins, B.Sc., 312 St. Clair Ave. W., Toronto.
Eric E. Wells, 496 Church St., Toronto 5.
Paul Williams, 1090 Shaw St., Toronto 4.

The passing of Mr. Arthur R. B. Knight was noted with regret.

Four interesting motion pictures were shown. These were entitled, "Solar Family", "Earth's Rocky Crust", "Clouds" and "Story of a Disturbance".

March 6, 1951.—The meeting was held in the McLennan Physics Laboratory. The Chairman was Mr. F. L. Troyer, President.

Three candidates were elected to membership in the Society. These were:
Miss Elizabeth McMillan, 35 Brunswick Ave., Toronto 4.
Donald G. Paterson, 124 Donlea Drive, Toronto 17.
Glen J. Doyle, 39 Herbert Ave., Toronto 8.

The speaker was Dr. H. C. Van de Hulst of Leiden, in the Netherlands. He spoke on, "Radio from Beyond the Earth".

Dr. Van de Hulst explained the nature of radio waves and of the antennae used to detect them. He discussed radio telescopes and some of their known limitations and advantages.

At present, radio emission from the sun is believed to originate in the chromosphere and corona. Valuable information has been obtained during solar eclipses. Actual solar spectra in radio wavelengths have been obtained by the Australian group of workers who make use of a convenient contour method for plotting their results, involving the three parameters, intensity, wavelength and time.

Radio signals from outside the solar system have been received. An interferometer device employing direct waves and waves reflected from the ocean's surface demonstrates whether or not the signal comes from an apparent point. Position can at best be estimated to 1/10°. The centre of the Milky Way is associated with a radio signal and the Andromeda Nebula has recently been detected at Manchester.

The speaker was thanked by Mr. R. L. Baglow.

W. R. Hossack, *Recorder.*

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